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Turbidity and Selected Water Quality Characteristics of the Fraser River at Hell's Gate, 1965-85

J. A. Servizi and R. W. Gordon

Department of Fisheries and Oceans
Biological Sciences Branch
Cultus Lake Salmon Research Laboratory
Cultus Lake, British Columbia V0X 1H0

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by

J. A. Servizi and R. W. Gordon

Department of Fisheries and Oceans
Biological Sciences Branch
Cultus Lake Salmon Research Laboratory
Cultus Lake, British Columbia VOX 1H0

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ABSTRACT

Servizi, J. A. and R. W. Gordon. 1989. Turbidity and selected water quality characteristics of the Fraser River at Hell's Gate, 1965-85. Can. Data Rep. Fish. Aquat. Sci. 755: 131 p.

Twenty years of turbidity, temperature and river gauge height data were obtained for the Fraser River at Hell's Gate, British Columbia. Conductivity and pH records covered ten years while suspended solids spanned six years. Turbidity ranged from relatively low values in winter to very high values during spring freshet. Large pulses of turbidity occurred on occasion and were believed caused by land slides.

RÉSUMÉ

Servizi, J. A. and R. W. Gordon. 1989. Turbidity and selected water quality characteristics of the Fraser River at Hell's Gate, 1965-85. Can. Data Rep. Fish. Aquat. Sci. 755: 131 p.

Des données sur la turbidité, la température et le niveau d'eau du fleuve Fraser ont été recueillies pendant vingt ans à Hell's Gate, en Colombie-Britannique. Des données concernant la conductivité et la teneur en pH des eaux ont été recueillies pendant dix ans, alors que les données relatives aux matières en suspension dans l'eau ont été recueillies sur une période de dix ans. Le taux de turbidité était relativement bas en hiver alors qu'il était très élevé pendant la crue nivale du printemps. Des glissements de terrain pourraient avoir parfois causé des hausses importantes du taux de turbidité.

**Turbidity and Selected Water Quality Characteristics of the
Fraser River at Hell's Gate, 1965-85**

INTRODUCTION

The Fraser River rises in the Rocky Mountains and flows 1368 km through the interior plateau and Coast Mountains to its mouth near Vancouver (Fig. 1). The Fraser River is highly turbid for most of the year owing to erosion. The majority of suspended solids at Hell's Gate were less than 5 microns (geometric mean diameter, Servizi and Martens, 1987).

Spawning migrations of Pacific salmon (*Oncorhynchus spp.*) occur in the Fraser River from April through November. Some pink (*O. gorbuscha*) and chum (*O. keta*) spawn in the Fraser River main-stem downstream of Hope. Seaward migrations of smolts and fry occur primarily in March, April and May as river flow and suspended solids increase owing to freshet.

As part of a program (International Pacific Salmon Fisheries Commission) to monitor selected water quality parameters, samples were collected at Hell's Gate between November, 1965 and October, 1985 by Commission personnel. Turbidity, temperature and river gauge height were measured throughout the study period on a nearly daily basis. Measurements of pH and conductivity commenced in November, 1975. Suspended solids (non-filterable residue) were measured commencing in January, 1979.

METHODS

Water samples were collected at midstream about one meter below the surface by lowering a weighted one litre container from the bridge at Hell's Gate. Water temperature was measured immediately upon collection using a mercury thermometer. River height was read from a fixed gauge. From November, 1965 through October, 1975, turbidity was measured immediately after collection using a Hellige Turbidimeter (SiO_2) calibrated to a Jackson Candle (Amer. Public Health Assoc. 1960). Commencing with November, 1975, samples were refrigerated and forwarded once per week via overnight express to the Cultus Lake Laboratory, International Pacific Salmon Fisheries Commission. Starting Sept. 22, 1976, turbidities were measured using a Nephelometric Turbidimeter, (HF Instruments Ltd., Model DRT 100). Turbidities of 401 samples were measured using the Hellige and Nephelometric turbidimeters between Sept. 22, 1976 and Oct. 4, 1978.

The conductivity and pH of samples were measured at Cultus Lake Laboratory commencing in November, 1975. Measurements of suspended solids started in January, 1979. Conductance was measured using an Industrial Instruments Model RC meter equipped with a cell having a nominal constant of unity (Amer. Public Health Assoc. 1960). The pH was measured using a glass electrode referenced to a saturated calomel electrode or a combination

electrode. Suspended solids were measured using a GF/C glass fibre filter (Amer. Public Health Assoc. 1980).

RESULTS AND DISCUSSIONS

Flow in the Fraser River is characterized by a winter minimum and a late spring maximum associated with runoff from snow melt (Anon. 1985). Autumn rains cause a minor increase in flow. Spring freshet commenced at the beginning of April and typically peaked in mid-June. These flow patterns are evident in gauge height readings at Hell's Gate (Fig. 2). Unseasonably warm temperatures and rain over the interior of the watershed can occasionally create mid-winter pulses in flow as seen for 1968 (Fig. 2a), 1980 (Fig. 2c) and 1981 (Fig. 2d).

Winter temperatures were usually less than 2°C but began a steady rise in early March to summer maxima in August in the range 16° to 19°C (Fig. 3). From September onward, temperatures typically declined to winter lows.

The annual trend for conductivity paralleled the seasonal flow regime (Fig. 4). Conductivity was typically greater during low winter flows, when groundwater would form a relatively greater proportion of the flow. With the onset of freshet in April, and increasing flows of snowmelt, conductivity began a decline to summer minima. Conductivity increased slowly through autumn into winter. The winter of 1980-81 was atypical, however, as conductivity declined in December and continued at the lowest winter levels in the years of record. Conductivities were undoubtedly low because river flows were higher than normal, commencing in December 1980 and continuing into March 1981 (Fig. 2c, d).

Turbidities in the Fraser River ranged from minima during winter low flow to maxima during spring freshet (Fig. 5). Typically, turbidities began to increase in March or early April and reached maxima in late May in advance of peak river flows. The timing of turbidity and flow suggests that sediments were washed into the river as flows increased. Three large pulses of turbidity occurred in late summer after the peaks; in August 8, 1976 (480 SiO₂ units), August 23, 1977 (1,120 NTU) and July 20, 1981 (400 NTU). The causes of these turbidity pulses were not identified but were believed due to landslides.

Analysis of 401 turbidity samples were made using two different instruments, which measured turbidity as SiO₂ units and NTU. Linear regression analysis ($R = 0.977$) gave the following relationship;

$$\text{NTU} = 1.32 (\text{SiO}_2) - 8.50 \quad (\text{Fig. 6})$$

Owing to scatter about the regression line, care should be exercised when interpreting values calculated using this equation.

Turbidity and suspended solids analyses measure different characteristics but the two are often compared graphically to detect possible correlations (Lloyd, Koenings and LaPerriere, 1987). Suspended solids and

turbidity were measured for 332 samples starting in January 1979. The data appear to have lower and upper segments (Fig. 7). The data making up these segments are associated with spring freshets, but examination of sample dates revealed that neither segment was representative of any particular temporal grouping. Linear regression ($R = 0.9$) gave the following relationship;

$$SS = 3.91 (NTU) + 3.14$$

(Fig. 7)

However, scatter about the regression line would make prediction of suspended solids from turbidity, or vice versa, uncertain for any particular sample.

Turbidities are highly variable during spring and summer spawning migrations of adult Fraser River salmon. It is conceivable that high turbidities cause migrating adult to be more susceptible to capture by net fishermen in the Fraser Canyon. The authors are unaware of any studies to examine this question.

Spring and summer turbidities cause deposition of fine sediments in pink and chum salmon spawning grounds downstream of Hope. However, spawning salmon clean the gravel when spawning redds are created the following autumn. Low turbidities, as currently occur, are thus necessary in winter to assure adequate survival of incubating eggs and alevins. Alterations in the river environment which could increase winter turbidity levels would have serious negative consequences for mainstem spawning salmon.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the efforts and dedication of Robert Johnston and Hew Dunlop who collected samples at Hell's Gate. Ken Warkentin and Earle Stewart analyzed the samples. The authors also thank Vivian Ogilvie and David Barnes who tabulated the records and prepared the figures.

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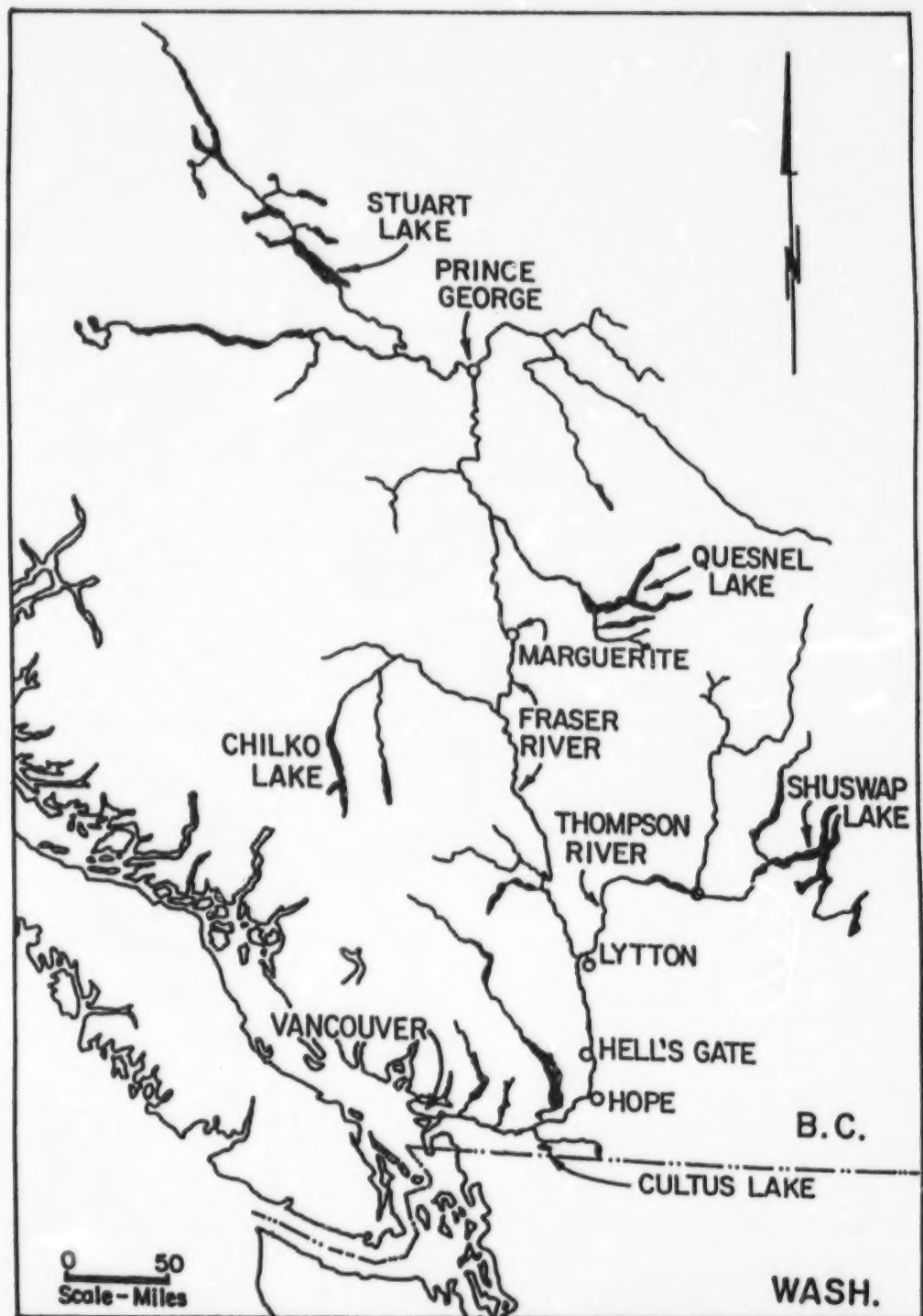


Fig. 1. Fraser River Watershed.

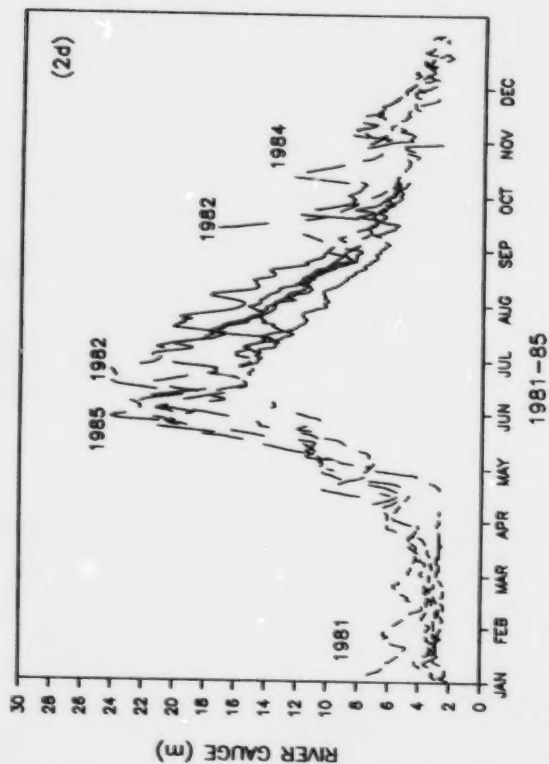
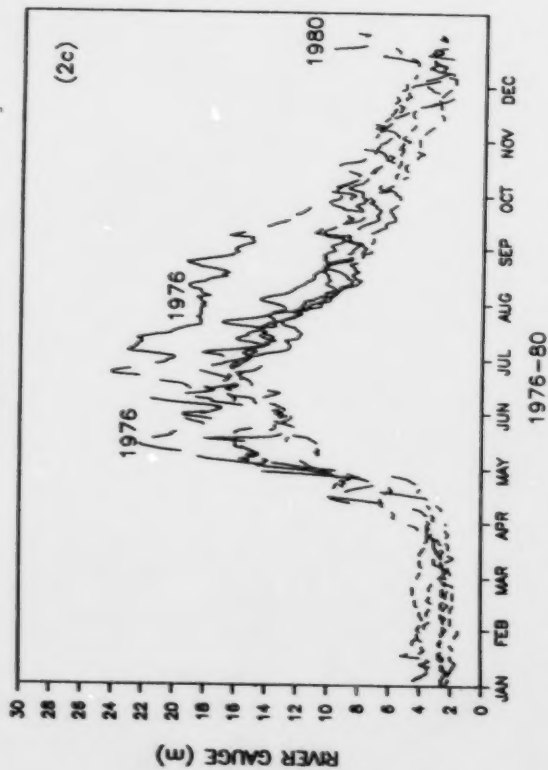
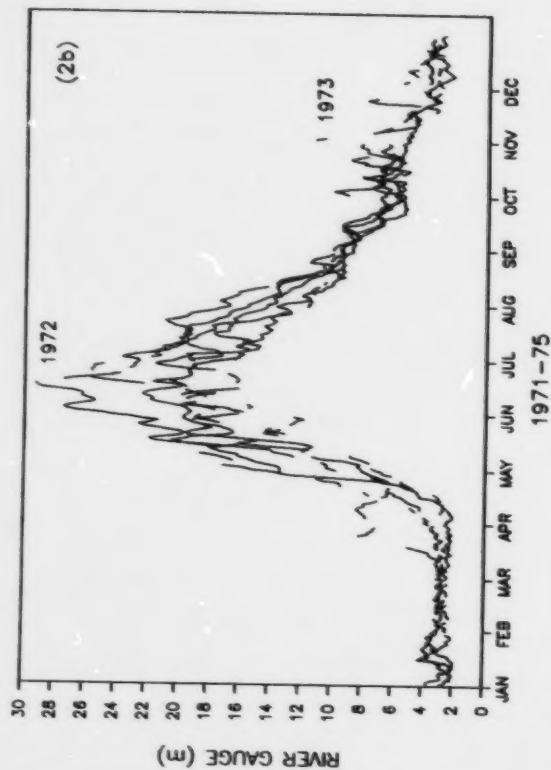
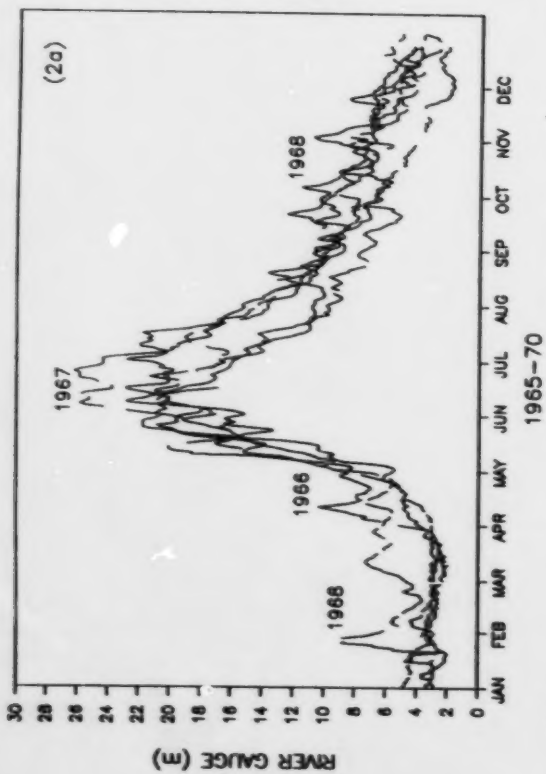


Fig. 2. Gauge height (m) of the Fraser River at Hell's Gate.

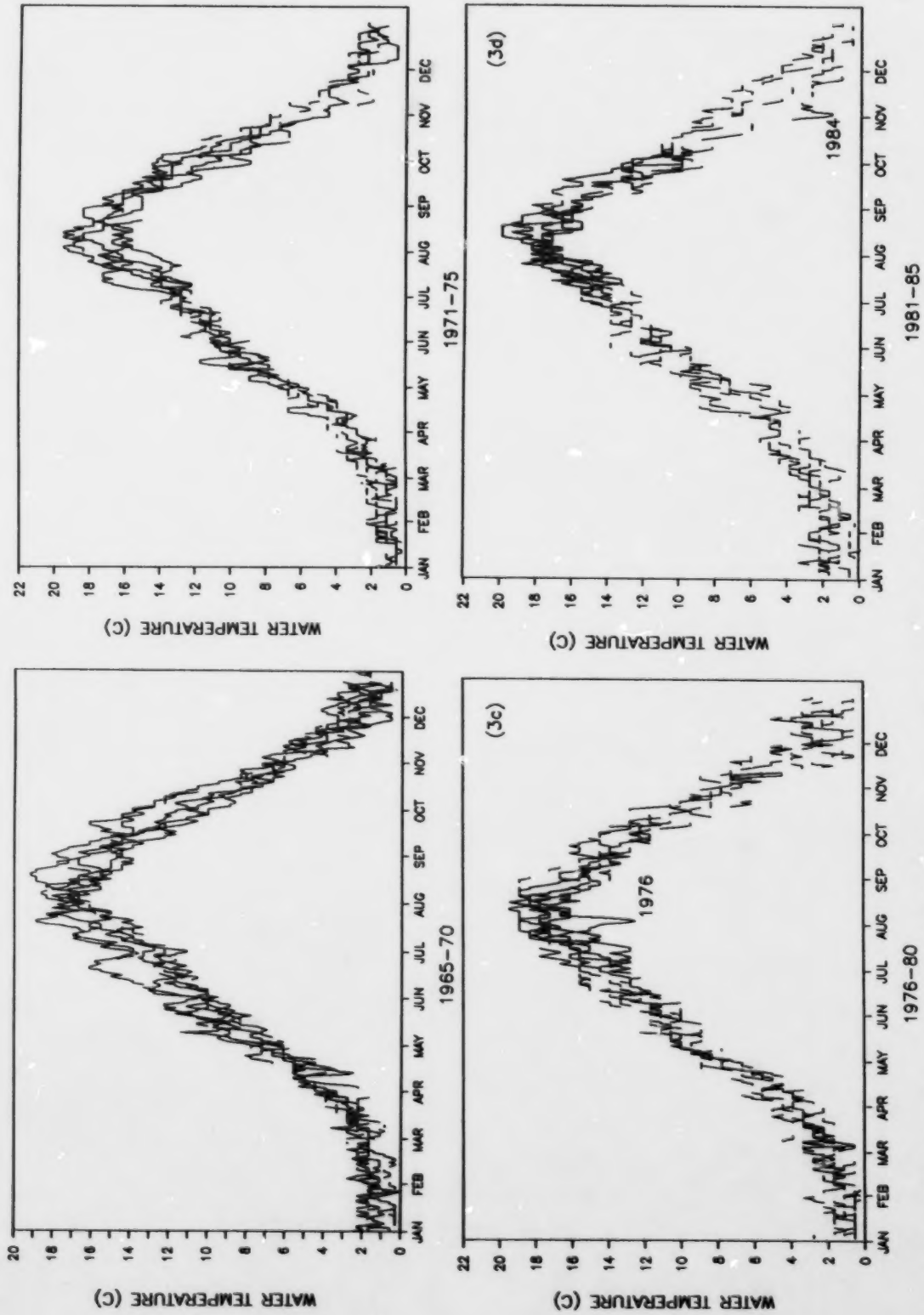


Fig. 3. Temperature ($^{\circ}\text{C}$) of the Fraser River at Hell's Gate.

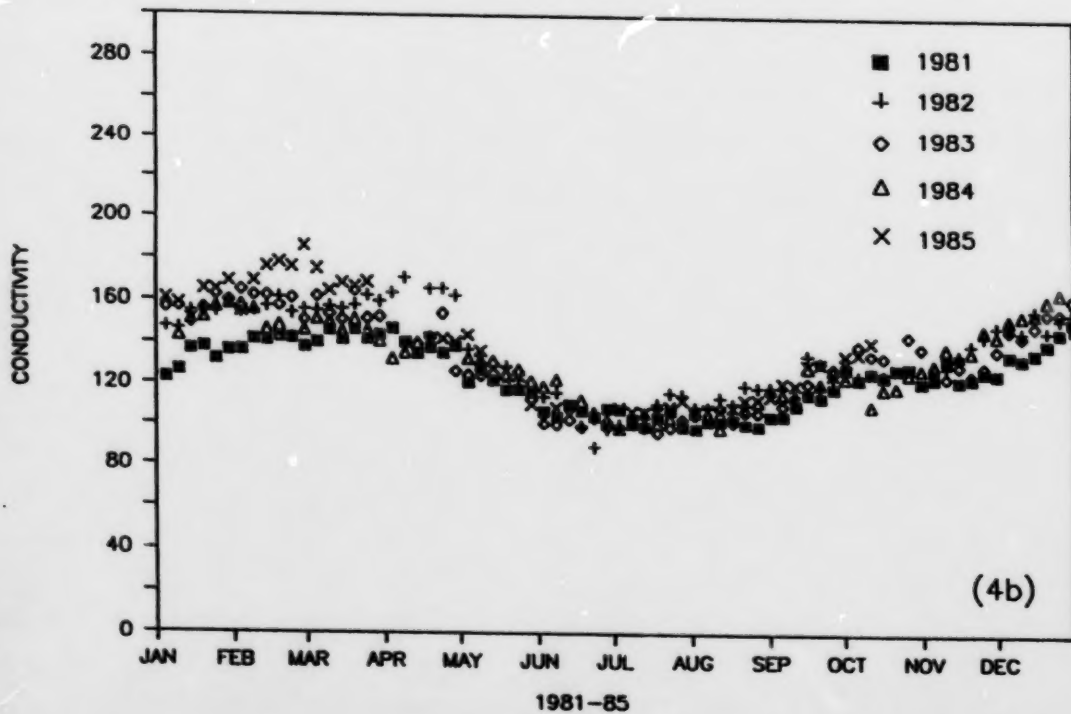
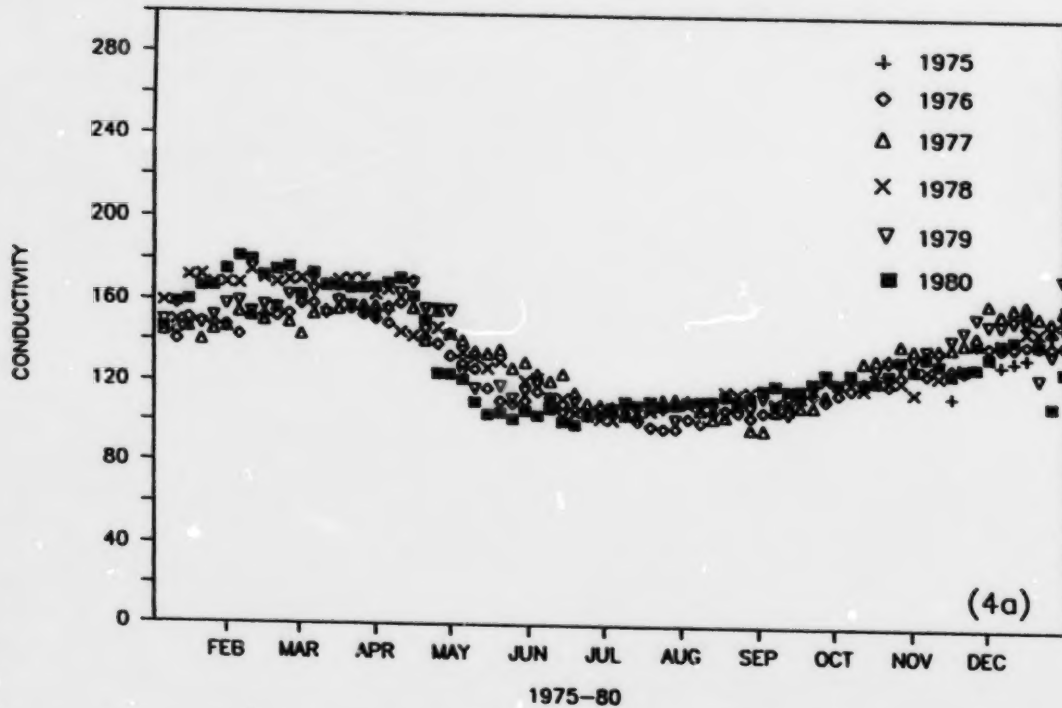


Fig. 4. Mean conductivity ($\mu\text{mhos}\cdot\text{cm}^{-1}$) of the Fraser River at Hell's Gate. Means represent five daily samples.

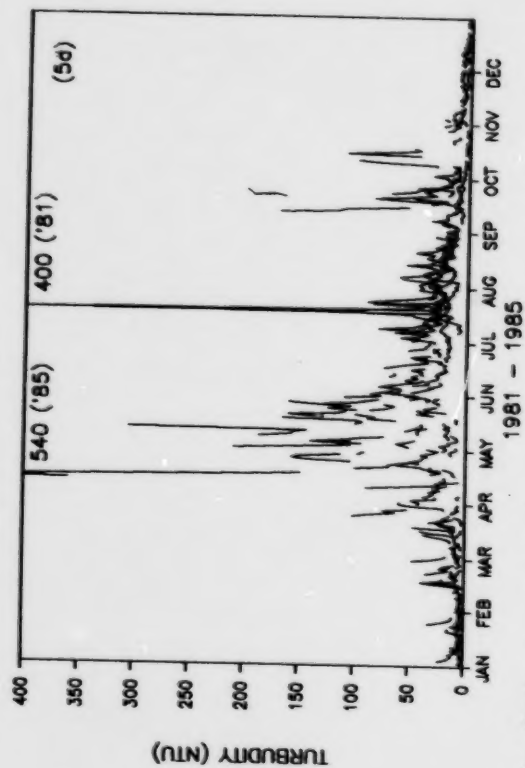
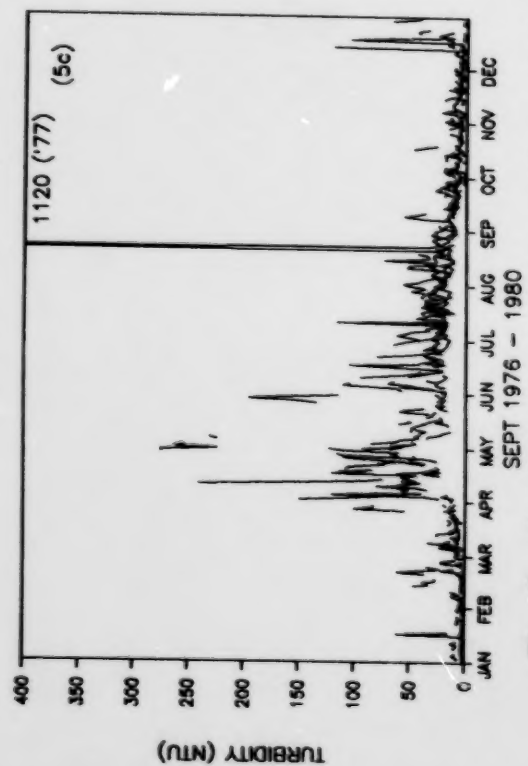
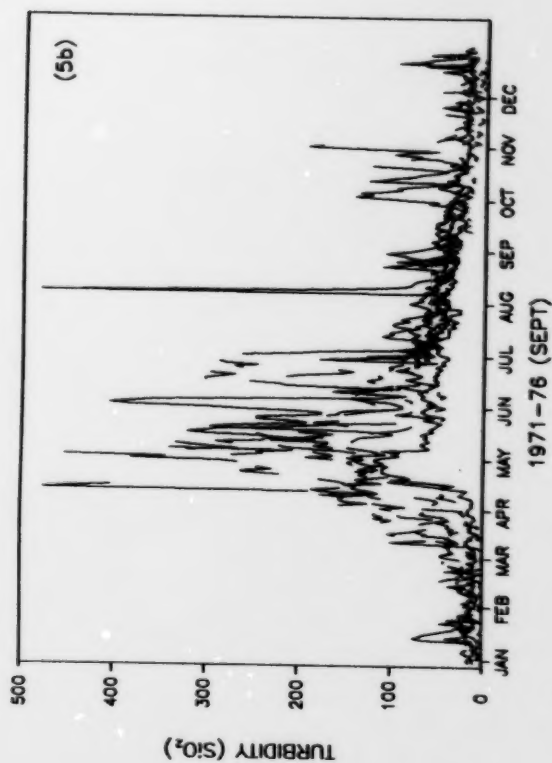
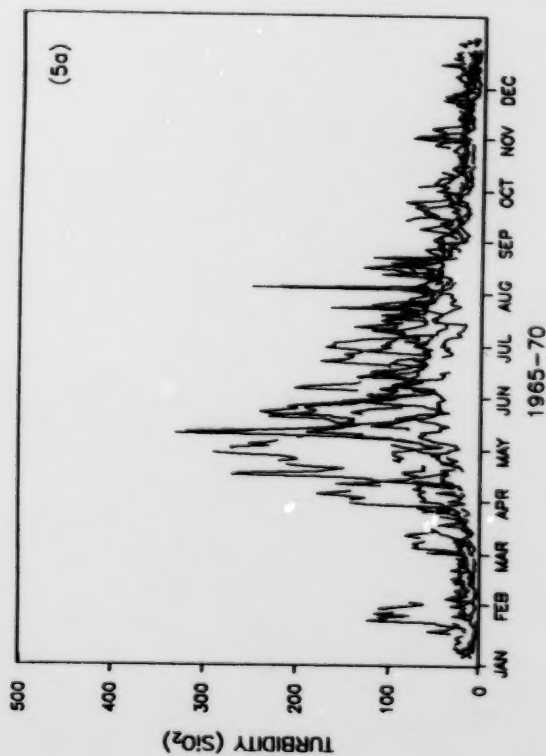


Fig. 5. Turbidity of the Fraser River at Hell's Gate expressed as SiO_2 units (5 a,b) and NTU (5 c,d).

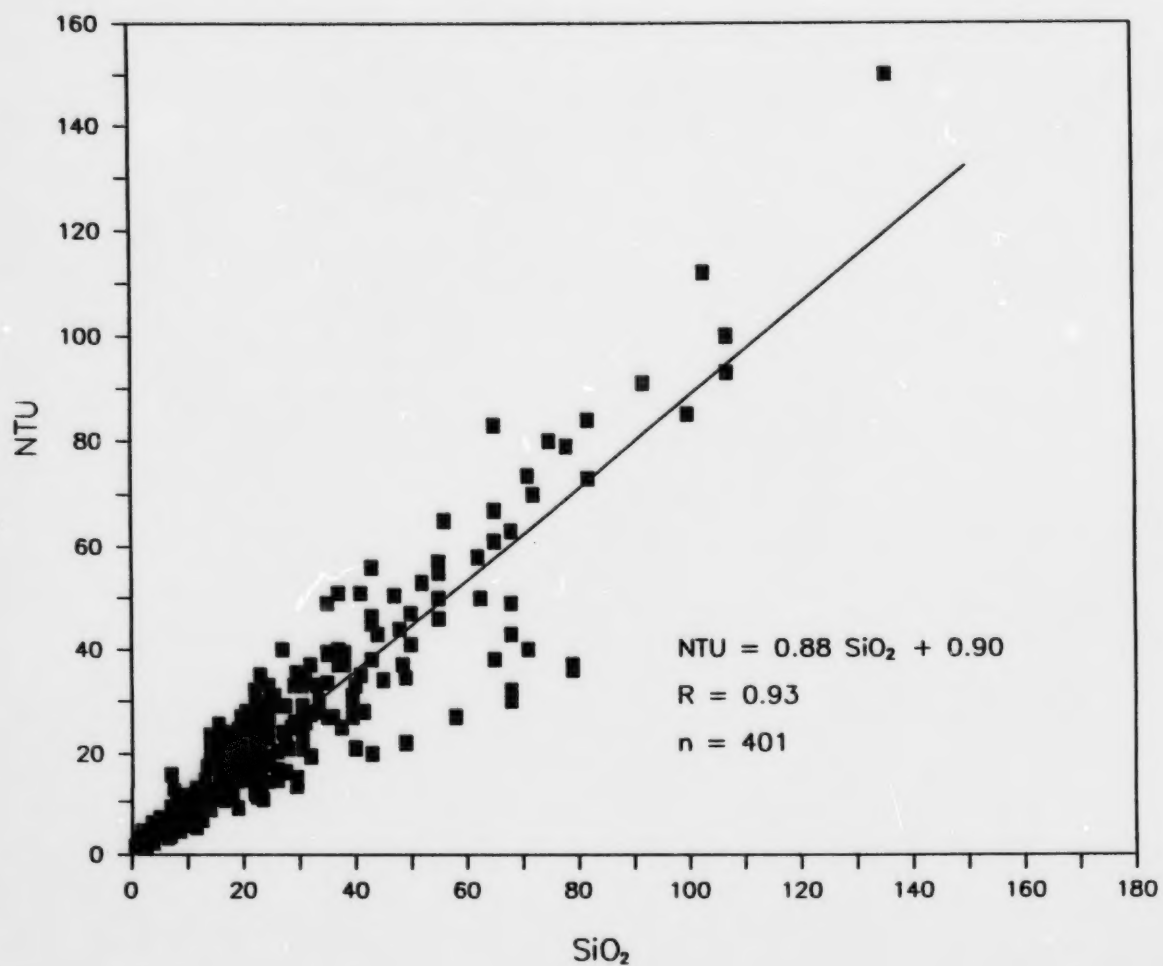


Fig. 6. Turbidities of 401 samples of the Fraser River at Hell's Gate measured in NTU and SiO_2 units.

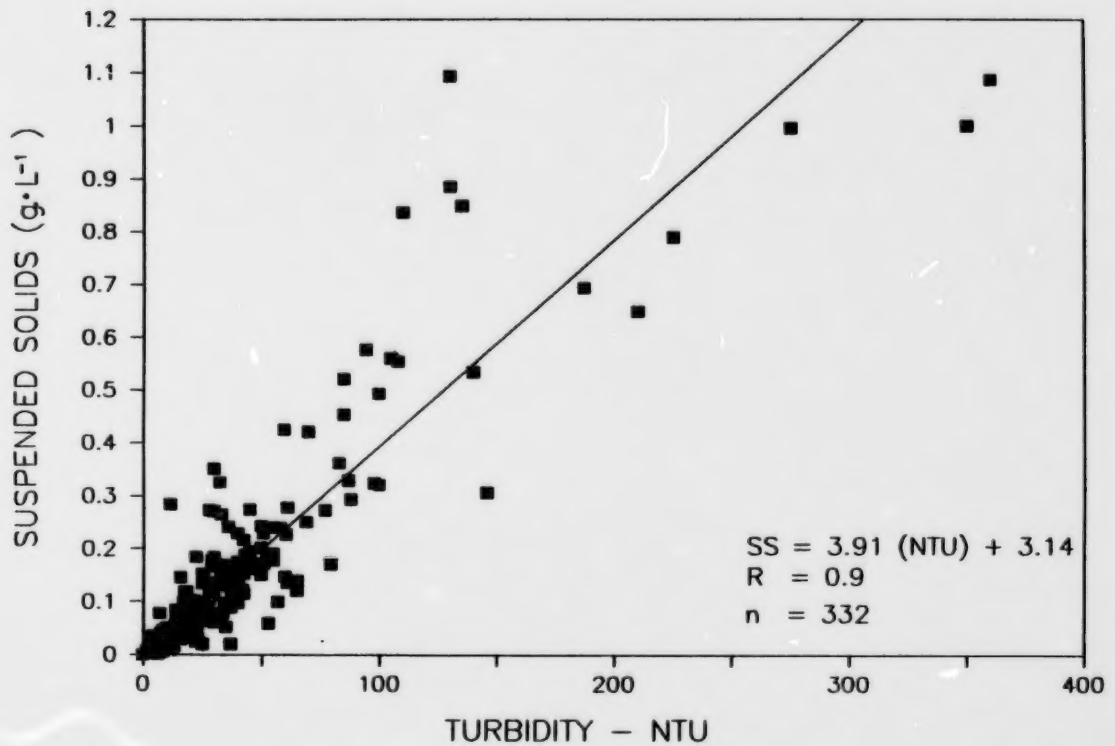


Fig. 7. Suspended Solids ($\text{g}\cdot\text{L}^{-1}$) and turbidity (NTU) at Hell's Gate, 1979-85.

Table A, page 12 through 131, does not appear in paper, but appears in microfiche form at the back of this report.